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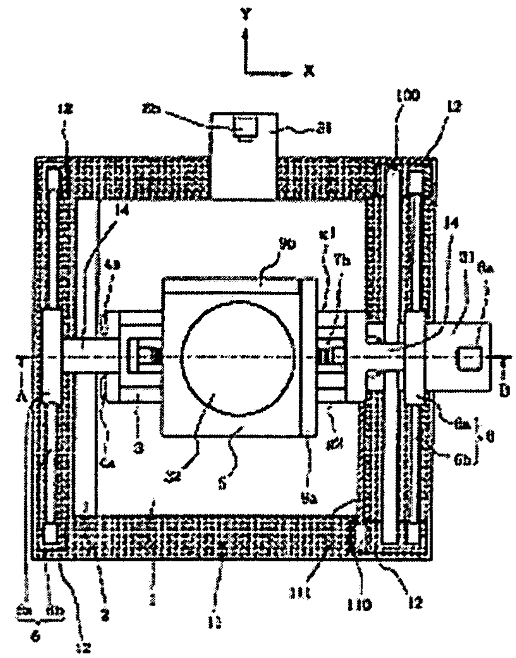
[54] [Title of Invention]

Feeding apparatus

[57] [Summary]

[Issue] To provide a feeding apparatus capable of high-speed, high-precision feeding and having a structure with high flexibility.

[Means of Resolution] The provision of stationary plate 1, first moving body 3 guided so as to be capable of moving in a first direction over a reference plane of said stationary plate, a first moving means that drives this in the first direction, second moving body 5 installed so as to be capable of moving in a second direction perpendicular to the first direction over the reference plane of the stationary plate relative to the first moving body and with an object mounted thereupon, second moving means 7 that drives the second moving body in the second direction, support means 100 that supports the second moving means in the second direction so that the second moving means can move only in aforementioned first direction parallel to the reference plane of the stationary plate independently of the first moving body, control means 110, 111 that drive the second moving means in the first direction, base pedestal 11 that supports the first moving means and support means, and vibration removal means 13 interposed between the base pedestal and the stationary plate.


Y
X
12
31
100
14
9b
7b
A
3
32
5
9a
6a
6b
6
2
110
111

[Scope of Patent Claim]

[Claim 1]

A feeding apparatus characterized by the provision of a stationary plate having a reference plane on the upper surface, a first moving body guided so as to be capable of moving in a first direction over the reference plane of aforementioned stationary plate, a first moving means that drives aforementioned first moving body in aforementioned first direction, a second moving body installed so as to be capable of moving in a second direction perpendicular to aforementioned first direction over the reference plane of aforementioned stationary plate relative to aforementioned first moving body and with an object mounted thereupon, a second moving means that drives aforementioned second moving body in aforementioned second direction, a support means that supports aforementioned second moving means in aforementioned second direction so that aforementioned second moving means can move only in aforementioned first direction parallel to the reference plane of aforementioned stationary plate independently of aforementioned first moving body, control means that drive aforementioned second moving means in aforementioned first direction, a base pedestal that supports aforementioned first moving means and aforementioned support means, and a vibration removal means interposed between aforementioned base pedestal and aforementioned stationary plate.

[Claim 2] The feeding apparatus of Claim 1 in which aforementioned control means drives aforementioned second moving means so as to virtually follow the movement of aforementioned first moving body in aforementioned first direction.

[Claim 3] The feeding apparatus of Claims 1 and 2 in which aforementioned first and second moving bodies are supported on aforementioned stationary plate via hydrostatic bearings.

[Claim 4] The feeding apparatus of Claims 1 to 3 in which aforementioned first moving body is guided in aforementioned first direction via hydrostatic bearings from the side of a first fixed guide that is fixed to aforementioned stationary plate.

[Claim 5] The feeding apparatus of Claims 1 to 4 in which aforementioned second moving body is installed on the side of aforementioned first moving body via hydrostatic bearings.

[Claim 6] The feeding apparatus of Claims 1 to 5 in which aforementioned first moving means is a linear motor that generates thrust by electromagnetic force, with the moving part coupled to aforementioned first moving body and the fixed member coupled to aforementioned base pedestal.

[Claim 7] The feeding apparatus of Claims 1 to 6 in which aforementioned second moving means is a linear motor that generates thrust by electromagnetic force, a mobile member being coupled to aforementioned second moving body and said means supported by aforementioned support means so that the fixed member can move only in aforementioned first direction over the reference plane of aforementioned stationary plate independently of aforementioned first moving body.

[Claim 8] The feeding apparatus of Claims 1 to 7 in which aforementioned support means has a second fixed guide that is fixed to aforementioned base pedestal and hydrostatic bearings wherein the guide surface is the bearing surface.

[Claim 9] The feeding apparatus of Claims 1 to 8 in which aforementioned stationary plate supports an optical system for exposure and in which aforementioned object is an exposed object.

[Detailed Description of the Invention]

[0001]

[Field of Industrial Utilization]

The present invention concerns a feeding apparatus capable of high-speed, high-precision movement and positioning of an object in various types of measuring instruments and in projection exposure equipment used, for example, in semiconductor lithographic procedures.

[0002]

[Related Art] Figure 12 is a schematic diagram showing an example of the structure of a conventional feeding apparatus. In the figure, reference numeral 51 represents a stage base upon which is mounted Y stage 52 as a movement mechanism in the Y direction (direction perpendicular to the plane of this paper) over stage base 51. Reference numeral 53 represents a DC servo motor fixed to stage base 51 that drives Y stage 52 following conversion of rotational movement into linear movement via a ball screw. Reference numeral 54 represents an X stage 54 that is mounted over Y stage 52. Reference numeral 55 represents a DC servo motor fixed to Y stage 52 that drives X stage 54 following conversion of rotational movement into linear movement via ball screw 56. Reference numeral 1 represents a stationary plate that supports stage base 51.

[0003] Reference numerals 9a, 9b represent reflecting mirrors fixed to X stage 54 for a laser measuring device. Reference numeral 8a represents an interferometer of the laser measuring device fixed to stationary plate 1 via

mounting pedestal 10 that detects the position in the X direction of X stage 54. Reference numeral 13 represents mounting members that support stationary plate 1 and that block the transmission of vibration from the base upon which the equipment is mounted. In aforementioned structure, the reaction force to the inertial force accompanying acceleration/deceleration is transmitted to stationary plate 1 upon driving of Y stage 52 and X stage 54.

[0004] The gazette of Patent Publication No. 05-077126 discloses a moving stage containing a stationary plate supported by a low-rigidity surface-plate support means, a movable stage supported by the stationary plate and a guide means, and a driving means mounted on the stationary plate that provides thrust to this movable stage, said stage provided with a driving means that provides thrust to the movable stage and a support means that supports said driving means independently of the stationary plate.

[0005]

[Problems Solved by the Invention] However, the natural frequency of the mechanism supported by mounting members is excited when support reaction force accompanying acceleration/deceleration of the moving body is transmitted to stationary plate 1 in the conventional example presented in aforementioned Figure 12. As a result, stray vibration is transmitted to X stage 54, Y stage 52, interferometer 8a, etc., which tends to obstruct high-speed, high-precision feeding.

[0006] In addition, the structure in the gazette of Patent Publication No. 05-077126 is configured so as not to transmit support reaction force to the stationary plate upon which a moving body is mounted accompanying acceleration/deceleration of the moving body, but the stage mechanism is restricted.

[0007] The purpose of the present invention is to improve aforementioned known device (in the gazette of Patent Publication No. 05-077126) by providing a feeding apparatus with a highly flexible structure.

[0008]

[Means of Solving the Problems and Effects] In order to attain aforementioned objective, the present invention is provided with a stationary plate having a reference plane on the upper surface, a first moving body guided so as to be capable of moving in a first direction over the reference plane of aforementioned stationary plate, a first moving means that drives aforementioned first moving body in aforementioned first direction, a second moving body installed so as to be capable of moving in a second direction perpendicular to aforementioned first direction over the reference plane of aforementioned stationary plate relative to aforementioned first moving body and with an object mounted thereupon, a second moving means that drives aforementioned second moving body in aforementioned second direction, a support means that supports aforementioned second moving means in aforementioned second direction so that aforementioned second moving means can move only in aforementioned first direction parallel to the reference plane of aforementioned stationary plate independently of aforementioned first moving body, control means that drive aforementioned second moving means in aforementioned first direction, a base pedestal that supports aforementioned first moving means and aforementioned support means, and a vibration removal means interposed between aforementioned base pedestal and aforementioned stationary plate.

[0009] Aforementioned structure realizes high-speed, high-precision feeding of a moving body without the transmission of inertial force to the stationary plate accompanying acceleration/deceleration of the moving body.

[0010]

[Embodiments of Invention]

(First embodiment) Figure 1 is a planar figure showing the feeding apparatus used in a semiconductor exposure device in a first embodiment of the present invention. Figure 2 is a cutaway drawing along A-B of Figure 1. Figure 3 is a planar figure showing the apparatus of Figure 1 excluding the top of the movable stage.

[0011] In these figures, reference numeral 1 denotes a stationary plate that supports an optical system for exposure with guide surface 1f on the upper surface. Reference numeral 2 denotes a fixed guide that is fixed to stationary plate 1 having a guide surface that is perpendicular to guide surface 1f of stationary plate 1 and parallel to the Y direction. Reference numeral 3 denotes a movable guide having guide surfaces g1, g2 perpendicular to guide surface 1f of stationary plate 1 and parallel to the X direction, with hydrostatic bearing pads 4a, 4b installed and non-contact support/guidance realized via the guide surfaces of stationary plate 1 and fixed guide 2. Reference numeral 32 denotes a chuck that fixes an exposed object (not illustrated) by a means such as vacuum attachment. Reference numeral 5 denotes a movable stage that holds chuck 32. Hydrostatic bearing pad 4c that is attached facing guide surface 1f of stationary plate 1 and hydrostatic bearing pad 4d that is attached facing guide surfaces g1, g2 of movable guide 3 permit contact-free support and guidance. Force is applied to hydrostatic bearing pads 4a, 4c via a means (not illustrated) such as magnetic attraction or vacuum attachment. Reference numerals 9a, 9b denote reflecting mirrors for a laser measuring device that are fixed to movable stage 5. Reference numerals 8a, 8b denote interferometers of laser

measuring devices that detect the position of movable stage 5, fixed to stationary plate 1 via mounting pedestal 10 and attachment base 31. Reference numeral 11 denotes a base pedestal that supports stationary plate 1 via mounting members 13 that block the transmission of vibration. Reference numeral 6 denotes two Y linear motors that drive movable guide 3 in the Y direction without contact. Y mobile members 6a are coupled to both ends of movable guide 3 via attachment plates 14. Y fixed member 6b is fixed to base pedestal 11 via frame 12. Reference numeral 7 denotes an X linear motor that drives movable stage 5 in the X direction without contact. X mobile member 7a is coupled to movable stage 5. X fixed member 7b comprises drive stage 99 that integrates couplings 106a, 106b and drive plate 105. Three hydrostatic bearing pads 102a, 102b, 102c in couplings 106a, 106b are attached via rods 103a, 103b, 103c that perforate movable guide 3. The pneumatic feed units to the individual hydrostatic bearing pads are not shown. Drive stage 99 is supported and guided without contact by guide surface 1f of stationary plate 1 via these three hydrostatic bearing pads 102a, 102b, 102c. Two hydrostatic bearing pads 101 and attachment means 104 using magnetic attraction or vacuum attachment are attached to drive plate 105, and drive stage 99 is guided without contact in the Y direction by second fixed guide 100 and supported in the X direction by these. Drive mechanism 111 is mounted in drive plate 105 and drive stage 99 is driven in the Y direction based on frame 12. Drive mechanism 111 may use ball screws, for example. Reference numeral 110 denotes a position detector for detecting the position of drive stage 99 in the Y direction, and may use an encoder, for example. Drive stage 99 can be moved via aforementioned structure independently in the Y direction relative to movable guide 3 and movable stage 5 within the range ($\pm\delta$) of perforation holes 107a, 107b in movable guide 3. Furthermore, movable guide 3 and movable stage 5 are unaffected by movement of drive stage 99.

[0012] Figure 4 is a partial enlargement of Y linear motor 6. Figure 5 is a cutaway drawing along C-D of Figure 4. Y mobile member 6a consists of magnetic material. A set of permanent magnets 6c facing the N pole and S pole is attached via a plurality of sets of adhesions and a magnetic circuit is completed so that magnetic flux would be formed as indicated by arrow H. A plurality of coils 6d is fastened to Y fixed member 6b, and permanent magnets 6c are located so that coil 6d would be positioned in the opposing space. X linear motor 7 has a similar structure. These linear motors are multipolar linear motors as presented in the gazettes of Japanese Kokai Publication Hei-01-185157 and Japanese Kokai Publication Hei-01-185158.

[0013]

Figure 6 is a block diagram showing the control means for driving movable stage 5 and drive stage 99 in the Y direction. Reference numeral 50 denotes a controller for driving movable stage 5 and movable guide 3 in the Y direction. Reference numeral 52 denotes a driver that supplies current to coil 6d of the Y linear motor. Electromagnetic force drives movable stage 5 and movable guide 3 in the Y direction as a function of the amount of current supplied from driver 52, while reaction force is applied to frame 12 via Y fixed member 6b. At this time, Y fixed member 6b vibrates and induction voltage is created in coil 6d when relative velocity develops with mobile member 6a, but vibration from Y fixed member 6b is not transmitted to mobile member 6a since driver 52 maintains the current flowing through coil 6d at a value as a function of a command signal. The amount of current from driver 52 constitutes a value in response to the deviation between the Y standard position of movable stage 5 and the Y position determined by feedback of the Y position to controller 50a, which is the output signal of a laser measuring device that measures the position in the Y direction. Drive of movable stage 5 and movable guide 3 in the Y direction is controlled in this manner.

[0014] Furthermore, the drive of drive stage 99 is controlled using the Y standard value that is shared with movable stage 5 and the output signal of an encoder, position detector 110, as the feedback signal of drive stage 99 to enable drive stage 99 to enable drive stage 99 to follow movable guide 3. Reference numeral 51 denotes a controller that controls drive mechanism 111 that used ball screws based on the deviation between the Y standard value and the feedback signal. No problem arises if drive stage 99 could follow movable guide 3 at an error of 1/3 to 1/4 of the range $\pm\ \delta$ of aforementioned perforation holes 107a, 107b, for example.

[0015] Movable stage 5 and movable guide 3 complete prescribed movement in the Y direction when a prescribed Y standard value or standard pattern is input in aforementioned structure. Furthermore, drive stage 99 completes prescribed movement virtually following movable guide 3 at this time. The inertial force accompanying acceleration/deceleration of movable stage 5 and movable guide 3 when driven in the Y direction is transmitted to frame 12 via Y fixed member 6b of the linear motor as the reaction force in the Y direction but it is not transmitted to stationary plate 1 that is supported on base pedestal 11. Furthermore, the inertial force accompanying acceleration/deceleration when movable stage 5 is driven in the X direction is transmitted to drive stage 99 containing X fixed member 7b of the linear motor as the reaction force in the X direction. It is transmitted to frame 12 via

hydrostatic bearing pads 101 and second fixed guide 100 but reaction force is not transmitted to stationary plate 1 that is supported on base pedestal 11. Accordingly, the natural frequency of the mechanism that is supported on mounting members 13 is not excited and stray vibration is not transmitted to movable stage 5 or laser interferometers 8a, 8b.

[0016] (Second embodiment) Guide surface 1f of stationary plate 1 serves as the reference with three hydrostatic bearing pads 102a, 102b, 102c located opposite in order to guide drive stage 99 in the first embodiment. In addition, two hydrostatic bearing pads 101 are installed, with second fixed guide 100 serving as the reference. However, a locked cylindrical hydrostatic bearing 121 may be installed in second fixed guide 100 instead of this, as shown in Figures 7 and 8, and this may be used with a guide structure comprising one hydrostatic bearing pad 102b facing guide surface 1f of stationary plate 1.

[0017] (Third Embodiment) In addition, upper surface 3f of movable guide 3 may be used as the reference instead of using guide surface 1f of stationary plate 1 as the reference, as shown in Figure 9, and drive stage 99 may be guided by one opposing hydrostatic bearing pad 102b. Perforation hole 107 need not be installed in movable guide 3 by so doing, and that facilitates assembly.

[0018] (Fourth Embodiment) In addition, drive stage 99 may be supported on guide 100 and guided using rectangular hydrostatic bearing mechanism 131, as shown in Figure 10. By so doing, the tolerances of drive stage 99 other than in the Y direction (X, Z, X axial rotation, Y axial rotation, Z axial rotation) can be regulated solely by one rectangular hydrostatic bearing mechanism 131, and hydrostatic bearing pads 102a, 102b, 102c, 102b' that were used in the second and movable guide 3 embodiments can be eliminated.

[0019] (Fifth Embodiment) Second fixed guides 100, 100' are located on both sides of stationary plate 1, and drive stage 99 is supported via locked cylindrical hydrostatic bearings 121, 121' that are installed thereupon, as shown in Figure 11. This eliminates the need for hydrostatic bearing pads similarly to the fourth embodiment.

[0020] (Sixth Embodiment) Ball screws were used as drive mechanism 111 of drive stage 99 in the first embodiment, but a multipolar linear motor like that used in the first embodiment, for example, may be used as a non-contact actuator when greater cleanliness is required.

[0021]

[Effects of Invention] In the present invention, the first moving means, for example, the fixed member of a linear motor for driving in the Y direction, is supported and fixed by a base pedestal that is separated from a stationary plate that supports a second moving means, for example, a movable stage or an interferometer, by a vibration removal means (mounting members), and the second moving means, for example, the fixed member of a linear motor for driving in the X direction, is supported in the second direction (X direction), for example, by a second fixed guide so that it can move in the first direction (Y direction) independently of the first moving body, for example, a movable guide. Accordingly, the second moving means is driven so as to virtually follow the movement in the first direction of the first moving body. As a result, the inertial force accompanying acceleration/deceleration of the first moving body and the second moving body is not transmitted to the stationary plate. This results in high-speed, high-precision feeding without excitation of the various types of natural frequencies that comprise stray vibration.

[Brief Description of Drawings]

[Figure 1] A planar figure showing the feeding apparatus used in the first embodiment of the present invention.
[Figure 2] A cutaway drawing along A-B of Figure 1.
[Figure 3] A partial planar figure showing the apparatus of Figure 1.
[Figure 4] A partial enlargement of the Y linear motor in Figure 1.
[Figure 5] A cutaway drawing along C-D of Figure 4.
[Figure 6] A block diagram showing the control means for driving the movable stage and the drive stage of the apparatus of Figure 1 in the Y direction.
[Figure 7] A cutaway drawing of the feeding apparatus in the second embodiment of the present invention.
[Figure 8] A partial planar figure of the apparatus of Figure 7.
[Figure 9] A cutaway drawing of the feeding apparatus in the third embodiment of the invention.
[Figure 10] A cutaway drawing of the feeding apparatus in the fourth embodiment of the present invention.
[Figure 11] A cutaway drawing of the feeding apparatus in the fifth embodiment of the present invention.
[Figure 12] A schematic diagram showing a constituent example of a conventional feeding apparatus.

[Explanation of the Notation]

1f: guide surface, 1: stationary plate, 2: fixed guide, 3: movable guide, 4a, 4b, 4c, 101, 102a, 102b, 102c, 102b': hydrostatic bearing pads, 5: movable stage, 6, 7: linear motor, 8a, 8b: laser interferometers, 11: base pedestal, 12:

frame, 13: mounting members, 32: chuck, 99: drive stage, 100: second fixed guide, 110: position detector, 111: drive mechanism, 121, 121': locked cylindrical hydrostatic bearing, 131: rectangular hydrostatic bearing mechanism.

Figure 1

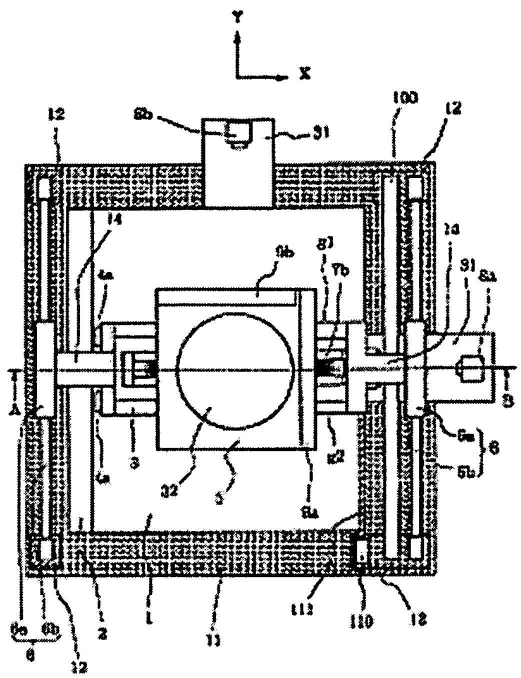


Figure 2

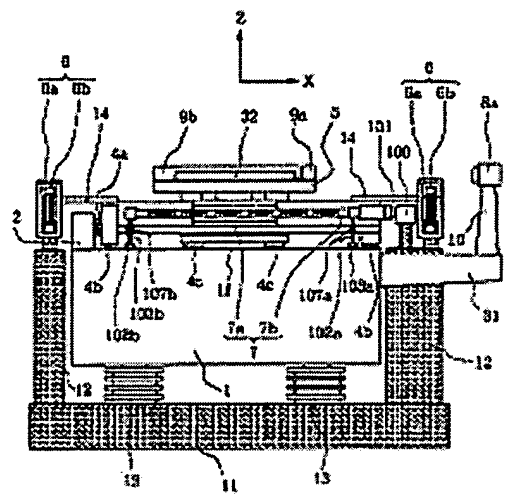


Figure 3

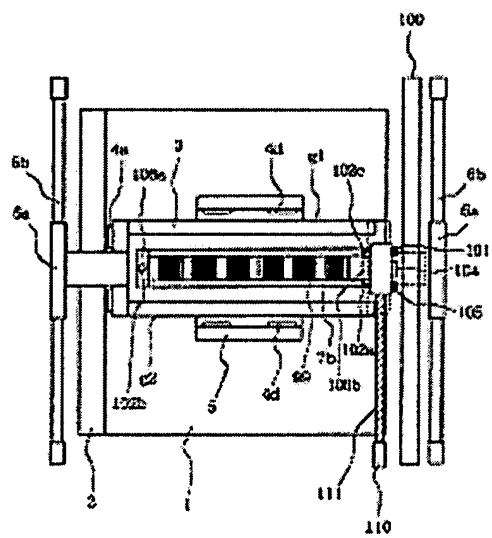


Figure 4

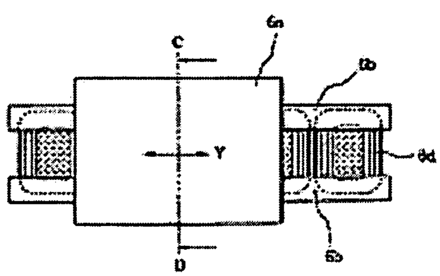


Figure 5

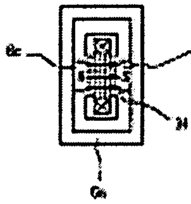


Figure 6

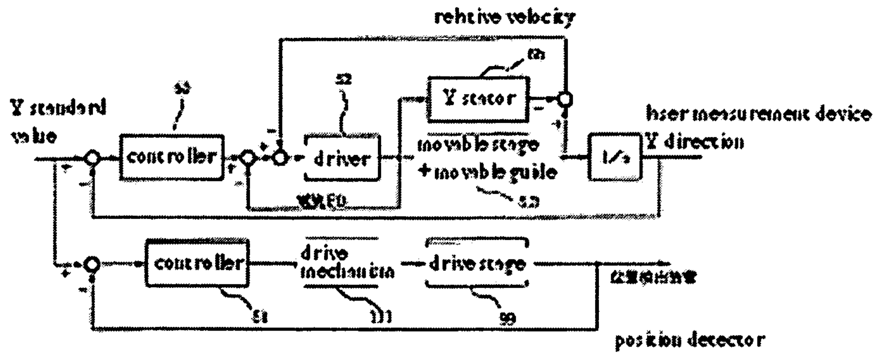


Figure 7

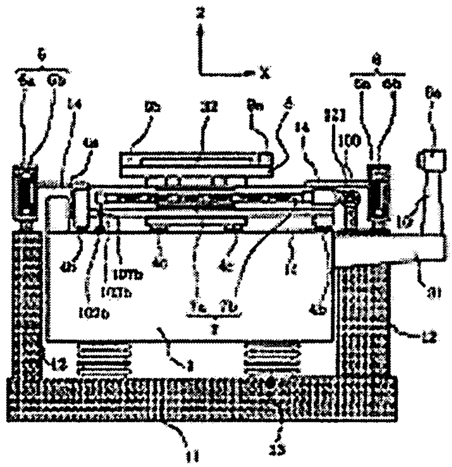


Figure 8

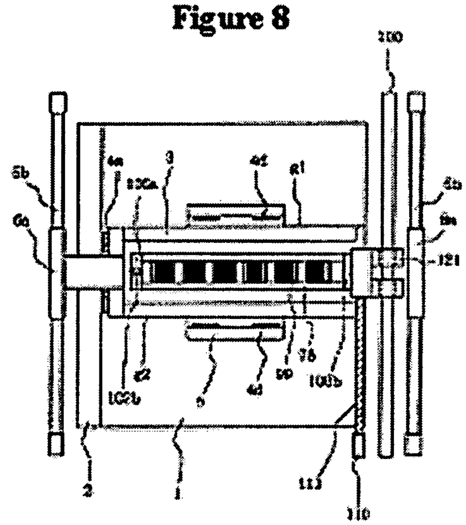


Figure 9

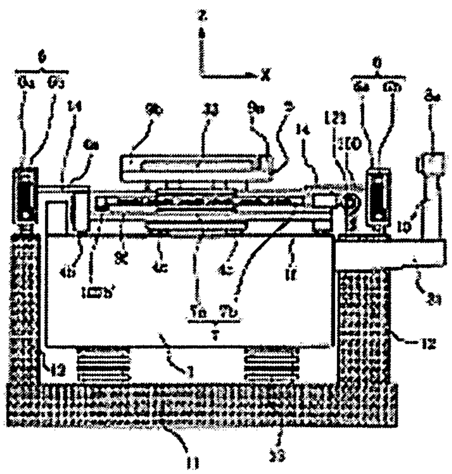


Figure 12

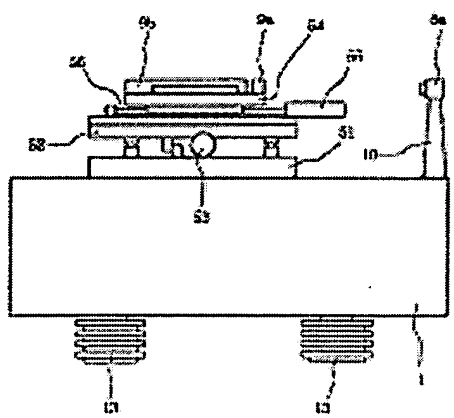


Figure 10

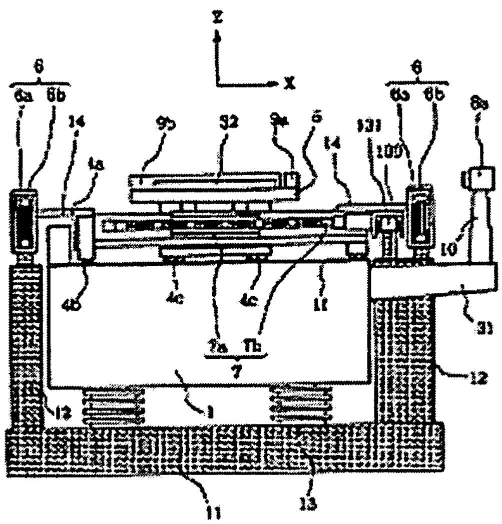


Figure 11